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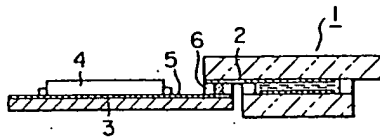
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(54) Liquid crystal display device

(57) A liquid crystal display device includes a sheet-like connector member (6) interposed between electrode terminals (2) juxtaposed on an end portion of a liquid crystal display cell (1) and signal terminals (5)

juxtaposed on an end portion of a driving circuit board (3). The sheet-like connector member is formed of a sheet of thermosetting adhesive which contains parts of conductive material embedded therein for providing electrical connection between the corresponding electrode and signal terminals.

FIG. 1



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FIG. 1

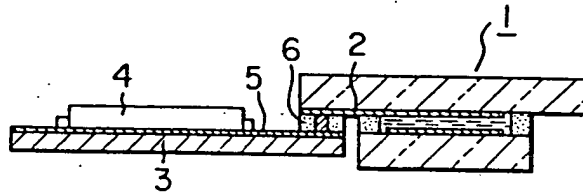


FIG. 2A

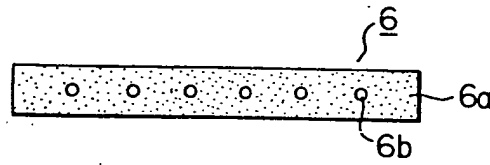
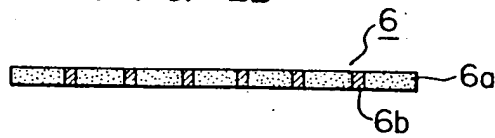


FIG. 2B



## SPECIFICATION

## Liquid crystal display device

The present invention relates to a liquid crystal display device, and more particularly to means for electrically connecting electrode terminals of a liquid crystal display cell to a driving circuit board.

In accordance with one conventional method of electrically connecting a liquid crystal display cell and a driving circuit board, metal connectors or conductive rubber connectors of pillar shape distributed between insulative rubber material are disposed between a number of electrode terminals juxtaposed on an end portion of the display cell and signal terminals juxtaposed on an end portion of the driving circuit board, and an electrical connection of the electrode terminals and the signal electrodes through the metal or rubber connector is realized by means of the application of a clamping pressure. In accordance with another method, a hot-melt or thermoplastic adhesive is used when a driving circuit board including connectors adhered to a flexible board such as a polyimide film is employed (see Japanese Patent Application 53-101776 filed on August 23, 1978 or the corresponding U.S. Application Serial No. 68,576 filed on August 22, 1979, assigned to the same assignee as the present application).

In the former method, however, a high clamping pressure is required when a large-size cell, especially, a cell such as a matrix type display cell including a great number of electrode terminals and having a long side along which the terminals are provided, is used. Therefore, the cell is subjected to its damage. Further, it is difficult to uniformly apply the clamping pressure to all of the terminals, which leads to poor electrical connection. Furthermore, when the pitch of the terminals on the cell or the driving circuit board is extremely small, undesirable contact between adjacent terminals frequently takes place and hence high reliability cannot be expected. In an assembly fabricated in accordance with the latter method by which the above problems associated with the application of a clamping pressure can be solved, the thermoplastic adhesive may be readily attacked by oil, solvent or the like so that inferior connection or peeling-off takes place at room temperature. Further, so long as the used adhesive is of hot-melt or thermoplastic type, higher heat resistance cannot be expected. Furthermore, since the bonding strength of the adhesive greatly depends upon temperature, the adhesive substance may move by a small load at a temperature higher than the normal room temperature by 10° to 20°C and hence the peeling-off may take place.

An object of the present invention is to provide a liquid crystal display device having a connection structure in which the above problems in the conventional structures are eliminated and which permits reliable, sure electrical connection.

According to the present invention, there is provided a liquid crystal display device comprising,

65 a liquid crystal display cell containing a liquid crystal material sealed between opposite electrode substrates, a plurality of electrode terminals arranged on an end portion of said liquid crystal display cell, a driving circuit board for driving said liquid crystal display cell, a plurality of signal terminals arranged on an end portion of said driving circuit board corresponding to said electrode terminals, and sheet-like connector means disposed between said electrode terminals and said signal terminals, said connector means including conductive material parts which provide electrical connection between the corresponding electrode and signal terminals and thermosetting adhesive parts which are filled between said conductive material parts.

The present invention will now be explained referring to the accompanying drawings, in which:

Fig. 1 is a sectional view showing a main part of an embodiment of a liquid crystal display device according to the present invention; and

Figs. 2A and 2B respectively show plan and sectional views of a main part of the connector in the embodiment shown in Fig. 1.

In Fig. 1 showing an embodiment of a liquid crystal display device according to the present invention, reference numeral 1 generally designates a liquid crystal display cell containing a liquid crystal material sealed between opposite electrode substrates, numeral 2 a number of electrode terminals juxtaposed on an end portion of the cell 1, numeral 3 a driving circuit board provided with circuit elements 4 for driving the liquid crystal display cell 1, numeral 5 a number of signal terminals juxtaposed on an end portion of the upper surface of the driving circuit board 3, and numeral 6 a sheet-like connector member disposed between the electrode terminals 2 of the liquid crystal display cell 1 and the signal terminals 5 of the driving circuit board 3. The connector member 6 includes a sheet of thermosetting adhesive and is best shown in Figs. 2A and 2B. The connector member 6 may be formed in such a manner that circular cylinder-shaped through-holes having the same pitch as the electrode and signal terminals 2 and 5 are provided in a 100 to 1,000 micron thick adhesive sheet 6a of epoxy base containing a potential curing agent such as boron fluoride complex ( $\text{BF}_3$ -complex) salt for causing a hardening reaction at temperatures above a critical temperature, and the through-holes are filled with paste 6b of Ag powders containing hot-melt or thermoplastic resin. The connector 6 is first positioned in a manner that respective one-side ends of Ag paste 6b coincide with the signal terminals 5 of the driving circuit board 3 and the other-side ends thereof coincide with the electrode terminals 2 of the liquid crystal display cell 1. Thereafter, a load in the order of 4 kg/cm<sup>2</sup> is applied under the raised temperatures of 130° to 150°C, thereby hardening the adhesive sheet 6a. The hot-melt type Ag paste 6b is then hardened through natural cooling.

Facilitated operation of alignment between the

Ag paste 6b and the signal and electrode terminals and hence the subsequent hardening work may be achieved by applying a proper tackiness agent to the surfaces of the signal terminals 5 to which one-side ends of Ag paste 6b are to be adhered (and surface portions of the driving circuit board 3 between signal terminals) while applying a silane-coupling agent to the surfaces of the electrode terminals 2 to which the other-side ends of Ag paste 6b are to be adhered (and surface portions of the display cell 1 between electrode terminals).

In accordance with another example of the connector member 6, through-holes provided in a sheet of an epoxy base adhesive containing the above-described potential curing agent are filled with a thermosetting type of Ag paste containing a curing agent of dicyandiamide base. The sheet and the paste are hardened by the same process as the above-mentioned.

With the connector member 6 in which the adhesive sheet 6a and Ag paste 6b forming the connector member 6 adhere tightly to the liquid crystal display cell 1 and the driving circuit board 3 through the heating and pressing process, the connector 6 does not peel off and causes no inferior connection, thereby providing reliable electrical connection.

The Ag paste used may contain usually more than 30 vol.% of Ag powders, preferably, about 80 vol.% of Ag powders.

Though the paste containing silver (Ag) powders has been exemplified, a paste containing gold (Au), lead (Pb), or carbon (C) powders may be employed. In more detail, since no large current is required for driving the liquid crystal display cell 1 and hence no requirements of excellent conductivity are imposed on the conductive parts 6b of the connector member 6, any proper conductive material can be used for the powders contained in the paste.

Though the adhesive sheet of epoxy base resin has been exemplified, any proper thermosetting resin may be used. In order to improve the workability, the sheet may contain a base formed of, for example, a non-woven fabric or a polyester film.

Further, though the adhesive sheet has been exemplified as containing a potential curing agent, the thermosetting type of adhesive sheet may include a resin containing any proper thermosetting agent.

For the silane-coupling agent which may be applied to the terminal portions of the liquid crystal display cell before the connection between the adhesive sheet and the electrode terminals, it has been found that good results are obtained when  $\gamma$ -aminopropyltriethoxysilane or  $\gamma$ -glycidoxytrimethoxysilane dissolved in ethyl alcohol with a concentration of 0.5 to 10% by weight is applied to the terminal portions of the cell and then dried at a temperature of 60°C to

120°C. The thermal drying process can be substituted with a mere drying process by air. The silane-coupling agent is not limited to these two kinds but the most effective silane-coupling agent is selected depending upon a thermosetting resin used as the adhesive sheet.

The conductive material paste portions of the connector member have been shown as having circular cylinder shapes and being aligned in the same straight line. However, any pillar shape such as elliptic cylinder or square pillar may be employed and the paste portions may be arranged in a zigzag form when the pitch of the electrode and signal terminals is very small.

As has been explained in the foregoing, a liquid crystal display device according to the present invention includes, as a connector member between the terminals on a liquid crystal display cell and the terminals on a driving circuit board, a thermosetting adhesive sheet having paste of conductive material embedded therein, whereby high reliability and sure electrical connection are achieved.

#### CLAIMS

1. A liquid crystal display device comprising: a liquid crystal display cell containing a liquid crystal material sealed between opposite electrode substrates; a plurality of electrode terminals arranged on an end portion of said liquid crystal display cell; a driving circuit board for driving said liquid crystal display cell; a plurality of signal terminals arranged on an end portion of said driving circuit board corresponding to said electrode terminals; and sheet-like connector means disposed between said electrode terminals and said signal terminals, said connector means including conductive material parts which provide electrical connection between the corresponding electrode and signal terminals and thermosetting adhesive parts which are filled between said conductive material parts.
2. A liquid crystal display device according to Claim 1, wherein said thermosetting adhesive parts of said connector means comprise a resin containing a potential curing agent.
3. A liquid crystal display device according to Claim 2, wherein said potential curing agent is a boron fluoride complex salt.
4. A liquid crystal display device according to any one of the preceding claims, wherein said conductive material parts of said connector means comprise powders of conductive material mixed in a thermoplastic resin matrix.
5. A liquid crystal display device according to any one of claims 1 to 3, wherein said conductive material parts of said connector means comprise powders of conductive material mixed in a thermosetting resin matrix.
6. A liquid crystal display device according to

claim 4 or 5, wherein said powders include at least one of Ag, Au, Pb and C.  
7. A liquid crystal display device according to

claim 1 substantially as hereinbefore described with reference to Figures 1 or 2a or 2b of the accompanying drawings.

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